2005 ANNUAL REPORT ON THE PORT LUDLOW AREA GROUNDWATER MONITORING PROGRAM FOR PORT LUDLOW ASSOCIATES, LLC

February 2006

by

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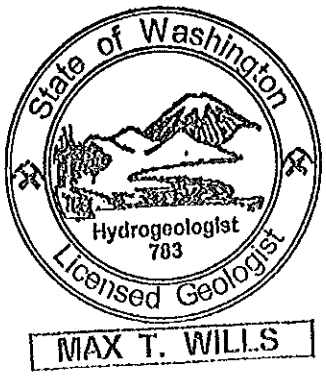

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Introduction

As a condition of plat approval, Jefferson County required that Port Ludlow Associates, LLC conduct a groundwater-resource monitoring program. To that end, Robinson, Noble, & Saltbush, Inc. was retained to develop, conduct, and supervise such a program. The program was initiated in April 1994 with the contacting of possible participants. The monitoring program concentrates on the North and South Aquifers (described below) and encompasses the area presumed to overlie these aquifers as well as a substantial area surrounding each aquifer. The current groundwater monitoring network is comprised of 18 wells owned and maintained by seven separate participants. In 2005, two wells were added to the monitoring network and no wells were deleted. In 2005, Olympic Water & Sewer, Inc. (OWSI, formerly Ludlow Water Company) completed two new production wells (Wells 15 and 16) in the South Aquifer. OWSI does not have immediate plans to use Well 15 for production, but is currently in the process of bringing Well 16 on line. Both Wells 15 and 16 were added to the monitoring network during 2005.

The goal of the monitoring program is to assess the long-term condition of the aquifers in the Port Ludlow area. The program focuses on collecting five basic parameters: 1) static water levels, 2) pumping water levels, 3) quantity of pumping, 4) water quality, and 5) rainfall. Water levels were initially taken twice a month during the summer months, and once a month during the rest of the year. The volume of water pumped from each of the wells in the network is recorded where available. Water quality samples were taken twice in the first year and annually thereafter. Rainfall measurements are being taken at the OWSI office. The following report provides an assessment of the data collected to date.

Modification of Monitoring Network in 2005

No modifications to the monitoring network were made in 2005 with regards to the frequency of measurements. Based on a recommendation given in 1995, the water-level measurement frequency for the monitoring network wells was reduced from its initial rate to quarterly and has remained so to date. OWSI wells continue to be measured on a monthly basis. Water quality monitoring is conducted on an annual basis. The Devine Well, one of several domestic supply wells in the monitoring network, was reconfigured in 2003 such that it could no longer be monitored, and it has not been subsequently replaced. In 2005, OWSI completed two new production wells, Wells 15 and 16, both of which have been added to the current monitoring network.

Port Ludlow Area Aquifers

Robinson, Noble, & Saltbush has conducted several studies in the Port Ludlow area evaluating the groundwater resources. In these previous studies, four principal aquifers were identified. These are the North, South, South Valley, and Well 1 aquifers (Robinson & Noble, 1987). The four aquifers were defined using differing methods dependent on the type and amount of information available.

A detailed explanation of the methods used can be found in Appendix E of the Port Ludlow Development Program EIS. The boundaries of the four area aquifers, and the locations of the wells that currently comprise the monitoring network, are shown on Figure 1.

Identification of Monitoring Wells

Robinson, Noble, & Saltbush developed a preliminary list of acceptable wells to be included in the groundwater monitoring network. These wells were selected to provide a comprehensive coverage of the area encompassing the aquifers. The preliminary list of wells included several of the OWSI wells and wells belonging to all known water purveyors operating around and within the boundaries of the North and South Aquifers. Also included were privately owned domestic wells located in areas of concern. Because some owners of wells on the preliminary list, including some water purveyors, declined to participate, a few additional private wells were subsequently added to the monitoring network.

Currently, OWSI withdraws water from only the North and South Aquifers. The water company's wells in the North Aquifer are completed from 139 feet above mean sea level (MSL) to 37 feet below MSL. Prior to 2005, OWSI's wells in the South Aquifer were completed from 12 to 84 feet below MSL. With the addition of Wells 15 and 16, the depth of completion in the South Aquifer was extended to 137 feet below MSL. In selecting other wells to monitor in the North and South Aquifer areas, the completion elevation of the well, and not simply the location, was a primary consideration.

In addition to monitoring the North and South Aquifers, the monitoring network includes three wells owned by OWSI located in and near the South Valley Aquifer. These wells allow long-term monitoring of the South Valley Aquifer, which currently has no active production wells.

Jefferson County Public Utility District (JCPUD) has an existing monitoring program for wells in the Shine area. Data from that monitoring program have been obtained and included in the Port Ludow monitoring network. Table 1 lists all of the wells included in the current monitoring network.

Discussion of Data Collected

Information gathered for each well is discussed below. For comparison purposes, the water level data for the monitoring network was compiled and plotted on similar scales. Water level data is referenced to individual measuring points, typically top of casing. The most recent water quality results are provided in Table 2. The historical trends and ranges for chloride and conductivity are discussed for each well. Note that the State drinking water standards for chloride and conductivity are 250 mg/l and 700 micromhos/cm, respectively. Rainfall data are also discussed in a separate section following the individual well discussions.

Olympic Water and Sewer, Inc. Monitoring Wells

Well 2

Well 2 is located in the North Aquifer. The static and pumping water levels and annual production are shown on Figure 2. The water level data show seasonal trends (short term / annual pattern) as generally declining in the summer and increasing (recharging) in the winter. Static water levels in Well 2 during 2005 ranged between 91.3 and 100.3 feet. The long-range water level pattern

shows a steady decline from 1972 to 1991, followed by a relatively constant level between 1991 and 1994. Starting in 1994, static water levels show a slightly increasing trend until 1999, a steady trend until the end of 2001, and a declining trend to present.

Table 1. List of wells in the Port Ludlow area monitoring program as of January 2004

Owner	Well name	Location	Aquifer area
Olympic Water and Sewer, Inc.	Well 2	T28N/R1E-8K	North
	Well 3	-8H	"
	Well 4N	-8P	"
	Well 4A	-21F	South Valley
	Well 9	-21F	"
	Well 12	-29A	"
	Well 13	-21R	South
	Well 14	-21R	"
	Well 15	-21R	"
	Well 16	-21R	"
Neault	Private	-15R	South
Woodruff (Hayden-Elaser)	Private	-8L	North
Jefferson County WD#1	Paradise Bay	-27G	South
Jefferson County PUD	Bywater #1	-34M	South
	Bywater #2	-35D	"
	Shine Plat #2	-33N	"
Hendrickson	Private	-34L	South
Hill	Private	-33Q	South

Between 1972 and 1994, static water levels and pumping water levels are generally parallel to one another. Starting in 1994, static and pumping water levels begin to show a slight divergence, with pumping levels remaining relatively constant while static levels increase. Starting in 1999, with static water levels relatively constant, pumping levels appear to decline. This divergence, or separation, becomes more pronounced starting in 2002, and then more so in 2003. Annual production for Well 2 has been fairly consistent since 1987, averaging approximately 23 gpm, but increased some in 2002 (27.9 gpm) and 2003 (30.4 gpm). Even with this higher production, the increasing separation of static and pumping water levels is indicative of a progressive loss in efficiency in the well. This loss of efficiency was verified with pumping tests conducted in 2004. Attempts were made at this time to rehabilitate Well 2, but because of several obstructions present in the well, rehabilitation was not possible. In 2004, following testing and rehabilitation efforts, Well 2 was equipped with a new pump, which has the intake set at a lower level to compensate for the efficiency losses in the well. The new pump has a higher instantaneous production rate than the previous pump. The average production from Well 2 in 2004 was 34.7 gpm, which was up from the two previous years. In 2005 the average production from Well 2 was 44.2 gpm, which is again up from previous years. At the higher pumping rates, pumping levels in Well 2 (as shown on Figure 2) are notably lower than the levels prior to the pump being replaced. With the new pump installed, static and pumping water levels do not currently appear to be diverging. However, several additional years of data are still needed to determine this conclusively.

Water quality results from Well 2 show that the chloride and conductivity have been variable (but low) throughout the history of the well, with no definite trend. Records dating back to 1968 show the chloride concentration has ranged from 3.7 to 11 mg/l and conductivity has ranged from 108 to 206 micromhos/cm.

Well 3

Well 3 is located in the North Aquifer. The static and pumping water levels and annual production are shown on Figure 3. Like Well 2, the water level data show the short-term seasonal trends as generally declining in the summer and recharging in the winter. Static water levels in Well 3 during 2005 ranged between 186.2 and 199.4 feet. The long-range water level pattern, particularly after 1980, indicate that there is a fairly strong responsiveness between water levels and production. Between 1980 and 1983, water levels rose, apparently in response to a reduction in production. Between 1983 and 1987, both production and water levels remained fairly stable. After 1987 and up through 1992, water levels fluctuate in apparent response to increases and decreases in annual production. After 1992, up through 2001, production and water levels again remain fairly constant. Starting in 1998, water levels actually begin to rise (with production constant), which is likely a reflection of increasing precipitation and associated recharge. After 2001 and up through the present, water levels decline markedly in an apparent response to increases in production (between 1992 and 2001, annual production ranged from 11.5 gpm to 14.7 gpm; in 2002, 2003, and again in 2004, production increased to 18.9, 23.3, and 27.2 gpm respectively). Production was actually decreased in 2005 to 24.3 gpm, but water levels continue to decline, likely in response to lower than average precipitation that has persisted since 2000.

Water quality results from Well 3 show that the chloride and conductivity have been fairly stable throughout the history of the well, with records dating back to 1986. Chloride concentrations have ranged from 2.0 to 9.9 mg/l, and conductivity has ranged from 155 to 227 micromhos/cm.

Well 4N

Well 4N is also located in the North Aquifer. Figure 4 shows the water level and production information for Well 4N. The short-term water level pattern for Well 4N exhibits a larger seasonal variation than in either Well 2 or Well 3. In 2005, the static water level ranged from 181.8 to 204.2 feet in mid summer. Similarly to Well 2, the long-term water level pattern for Well 4N show a slightly increasing trend from 1994 until 1999, then a steady trend until the end of 2001. After 2001 through present, water levels have been declining, apparently in response to increasing production. The average annual production rate at Well 4N steadily increased from 31.2 gpm in 2002 to 43.1 gpm in 2004. Production in 2005 decreased slightly to 39.9 gpm, but water levels in Well 4N still appear to be declining. Like Well 3, this declining trend is, to some degree, likely in response to lower than average precipitation that has persisted over the past six years. Water quality results from Well 4N show that the chloride and conductivity have been stable throughout the history of the well, with records dating back to 1980. The chloride concentration has consistently been less than 5 mg/l, and the conductivity has ranged from 149 to 204 micromhos/cm.

Well 4A

Well 4A is an inactive well located in the South Valley Aquifer. A hydrograph for the well is presented on Figure 5. In 2005, water levels measured in Well 4A were at or above the top of casing. This is consistent with the highest historical levels observed. Water quality results show the

chloride concentration has ranged from 5.0 to 6.5 mg/l, and the conductivity has ranged from 165 to 310 micromhos/cm.

Well 9

Well 9 is another inactive well located in the South Valley Aquifer. Its hydrograph is presented on Figure 6. In 2005, water levels in Well 9 ranged from 6.3 to 6.7 feet (measured in January and April only). This is comparable to the range in previous years, which show a stable trend since monitoring of the well began in 1994. Water quality results show the chloride concentration has ranged from 4.8 to 9.0 mg/l, and the conductivity has ranged from 150 to 245 micromhos/cm.

Well 12

Well 12 is also an inactive well located in the South Valley Aquifer. A hydrograph for Well 12 is presented on Figure 7. In 2005 the static water levels ranged from 4.9 to 5.2 feet (measured in April and January only). These levels are consistent with historical levels for this well. Water quality results show that the chloride concentration has ranged from 3.0 to 5.0 mg/l, and the conductivity has ranged from 77 to 120 micromhos/cm.

Well 13

Well 13 is located in the South Aquifer. Figure 8 presents the water level and production data for the well. Figure 8 shows that the static water level in Well 13 remained relatively constant until 1994. In 1994, the static water level appears to decline (or step-down) approximately three feet. This decline is likely due to a data error resulting from the change from airline readings to manual soundings in September 1994. At that time, a new pump was also installed in the well that provided a higher instantaneous production rate. As such, the pumping water level declined at this time as well. Following installation of the new pump, the static water level declined approximately two feet between 1994 and 1995. Since late 1995 through present, the static water level has been relatively stable. The pumping water level was also steady from 1995 through 1999, but declined through 2003. Production from Well 13 steadily increased from 1996, prior to the observed divergence between the static and pumping water levels. As such, the apparent separation of the static and pumping water levels was indicative of a loss of efficiency in the well. This loss of well efficiency was confirmed by testing conducted in 2003. Subsequent efforts to rehabilitate Well 13 were not successful and, consequently, production capacity has been curtailed since 2004. The average production in 2004 and 2005 was 35.2 and 31.7 gpm respectively, down considerably from 48.9 gpm in 2003. Two new production wells (Wells 15 and 16) were constructed in 2004/2005 to replace lost production from Well 13. At the time of this report, neither Well 15 nor 16 had been placed into permanent service. The seasonal fluctuation in Well 13 is fairly minimal as compared to OWSI wells completed in the North Aquifer. In 2005 the static water level in Well 13 ranged from 360.1 to 366.9 feet.

Water quality results from Well 13 show that the chloride and conductivity have been fairly steady throughout the history of the well. Records dating back to 1983 show the chloride concentration has ranged from 3.9 to 5.9 mg/l, and conductivity has ranged from 138 to 206 micromhos/cm.

Well 14

Well 14 is also located in the South Aquifer. Figure 9 presents the water level and production data for the well. Like Well 13, Figure 9 shows that there is minimal seasonal fluctuation in Well 14, as compared with the OWSI wells completed in the North Aquifer. In 2005 the static water level in Well 14 ranged from 374.1 to 375.9 feet. The long-term water level pattern shows that the static

water level gradually declined approximately one foot between the time the well was put on line in 1993 through 1998, but was stable thereafter through at least 2002. The current 2005 data indicate static water levels have decreased approximately two feet over the past three years. The pumping water level in this well has been steadily declining since 1996, which appears to correspond with a progressive increase in production over the same period. Unlike the diverging static and pumping water levels observed in Well 13, the divergence between the pumping and static water levels in Well 14 is likely in response to this steady increase in production. Annual average production in 2005 was 66.2 gpm, which is up from 76.5 gpm in 2004, and pumping water levels appear to have risen slightly in response.

Water quality results from Well 14, which date back to 1993, show that the chloride concentration has been stable, with values ranging between 0.3 and 7.9 mg/l. Conductivity has ranged from 141 to 200 micromhos/cm.

Well 15

Well 15 is also located in the south aquifer approximately 1,000 feet north of Well 14. Well 15 was constructed in early 2005 to replace declining production at Well 13. However, because of water quality issues related to arsenic and hydrogen sulfide odor, OWSI does not have immediate plans to put this well into service. Figure 10 presents an initial hydrograph of Well 15. At time of construction in February 2005, the static water level in Well 15 was 405.6 feet. Subsequent measurements in August 2005 indicate a seasonal fluctuation of approximately two feet, which is comparable to the fluctuation observed in Wells 13 and 14. Since Well 15 is not currently in service, no production data is presented.

Water quality results obtained during the initial testing of Well 15 show that the chloride concentration was 4 mg/l in 2005, and the conductivity was 184 micromhos/cm.

Well 16

Well 16 is located in the south aquifer approximately 100 feet southeast of Well 13. Like Well 15, Well 16 was constructed in the summer of 2005 to replace declining production at Well 13. OWSI is currently working to put Well 16 into permanent service. Figure 11 presents an initial hydrograph of Well 16. At time of construction in July 2005, the static water level in Well 16 was 376.0 feet. Subsequent measurements of this well have not been made so seasonal fluctuation has not been assessed. Considering the proximity of Well 16 to Well 13, however, it is expected that the seasonal fluctuation in these two wells will be comparable. Since Well 16 is not currently in service, no production data is presented.

Water quality results obtained during the initial testing of Well 16 show that the chloride concentration was 4 mg/l in 2005, and the conductivity was 169 micromhos/cm.

Private Wells

Woodruff (Hayden-Elaser) Well

The Woodruff well, now owned by Michael and Nancy Hayden-Elaser (but continued to be referred to herein as the Woodruff Well), is the only private well in the monitoring network completed in the North Aquifer. A hydrograph of this well is presented as Figure 12. The Woodruff well was reported to have been deepened at some point after initial construction to 219 feet. No water level information is available for the time of original construction. The water level measured

at the initiation of monitoring (May 17, 1993) was 151.2 feet. Subsequent water level measurements show a decline in summer months and rise in winter months. The variation may be in part a response to seasonal variation, as well as a response to seasonal pumping of wells in the immediate vicinity. The long-term water level pattern shows a general rise between 1994 and 1999 of approximately 10 feet. After that point water levels appear to be relatively stable until 2002 and then declining until present. In 2005, water levels ranged between 152.1 and 155.6 feet. Water quality analyses show that chloride concentrations have ranged from 2.5 to 5.9 mg/l. Conductivity has ranged from 152 to 221 micromhos/cm.

Devine Well

The Devine well is located on the northern fringe of the South Aquifer, near the shoreline of Port Ludlow Bay, in Ludlow Beach Tracts. In 2003 the wellhead for this well was reconfigured such that there is no longer access to measure water levels. The static water level measurements for this well through 2003 are shown on Figure 13. The original static water level at construction (May 14, 1980) was reported to be 39 feet. The initial water level measurement for the monitoring network (May 17, 1994) was 38.5 feet. With the exception of two water level measurements made in August 1994 (likely post-pumping recovery levels), the data show a slight rising trend (less than two feet) through 1999. The data collected after 1999 show a slight water level decline through 2000 and a leveling off through 2003. Water levels recorded for the last four years are consistent with the original static level and do not indicate an overall declining trend. Based solely on its proximity to the shoreline, this well is likely affected by tidal fluctuations to some degree. Seasonal fluctuation appears to fairly minimal. In 2003, water levels in the well ranged between 37.5 and 38.9 feet. Water quality analyses show that the chloride concentration has ranged from 3.0 to 7.5 mg/l, and the conductivity ranged from 223 to 320 micromhos/cm.

Neault Well

The Neault well is located on the fringe of the South Aquifer, near the shoreline of Puget Sound, at Tala Shores. The water levels measured in this well are presented in Figure 14. According to the State Water Well Report for this well, the original static water level at construction (January 25, 1978) was 15 feet. The initial monitoring network water level (June 1, 1993) was 31.5 feet. Subsequent water level measurements have been highly variable. This variability is likely caused by a complicated combination of factors including tidal influences, seasonal variation, and pumping activity. In 2005, measured water levels ranged between 19.9 and 22.4 feet. A number of off-trend (extremely low) water level measurements taken in 2002 and 2003 (also possibly in 2000 and 2001) are likely post-pumping recovering water levels and don't represent true static levels. The general long-term water level pattern for this well (estimating between the variations) appears to be increasing. Water quality analyses show that the chloride concentration has ranged from 3.9 to 10 mg/l. Conductivity has ranged from 185 to 250 micromhos/cm.

Hendrickson Well

The Hendrickson well, which replaced the Hodges well in the monitoring network in 1995, is a private domestic well located in the southern portion of the South Aquifer northeast of the Shine area. The water levels measured for this well are presented on Figure 15. The original static water level at construction (September 25, 1980) was reported to be 161 feet. In conjunction with the testing of JCPUD's Bywater Well 1, the Hendrickson well was monitored continuously from March 2 through 7, 1992. During that time period, the water levels varied between 159.8 to 160.2 feet, much of which appeared to be in response to barometric changes. The initial network water level (August 2, 1995) was 158.5 feet. In 2005, water levels ranged between 161.9 and 162.8 feet,

consistent with historical levels, which were relatively stable through 2000 and slightly declining since then. Water quality analyses show that the chloride concentration has ranged from < 5.0 to 11.8 mg/l, and the conductivity has ranged from 139 to 185 micromhos/cm.

Jefferson County Water District #1's Paradise Bay Well

The Paradise Bay Well is located in the central portion of the South Aquifer. Static water levels, and limited pumping water levels have been provided from 1994 through 2004 (Figure 16). No water level or production data was provided in 2005. Production data has been provided from 1994 through the present. The Water District reported that the static water levels in 2004 ranged between 321 and 322 feet, which was down slightly from the previous two years but within historical trends. Production records show a slight, but progressive, increase in production between 1997 and 2004. In 2005 the average continuous production rate was reported as 14.1 gpm, down slightly from 15.7 gpm during the previous year. Water quality analyses have been conducted quarterly since 1995. These analyses show the chloride concentration has ranged from 1.9 to 5.9 mg/l, and the conductivity has been between 116 and 154 micromhos/cm.

Jefferson County PUD's Monitoring Network Wells

Bywater Bay Well 1

Bywater Bay Well 1 is located in the South Aquifer area approximately 1¾ miles south of OWSI's Wells 13 and 14. This well is included in JCPUD's monitoring network and, for a time, was also monitored by Pope Resources. In 1997, Pope Resources deferred monitoring to JCPUD. The water level and production data collected for this well are shown on Figure 17. Production data was provided for this well for the first time in 2005, and therefore, the format of the hydrograph (Figure 17) has been modified from previous years to include production.

The initial network water level (May 22, 1992) was 163.6 feet. Relatively stable water levels were measured thereafter until 1999. After 1999, the measured water levels have been lower, though some of these water levels appear to represent pumping or post-pumping recovering water levels. The anomalously low water level measured on July 1, 2002 (206.7 feet) almost certainly represents a pumping water level and has been plotted as such. In 2005 water levels ranged between 173.9 feet and 180.1 feet. Unless all measured levels after 1999 represent pumping or recovering water levels, there appears to be a declining water level trend over the past six years. The next closest well in the monitoring network (Hendrickson well), however, shows a relatively stable trend for this period, as do Wells 13 and 14. Therefore, it is likely that this declining trend (if actually present) would be in response to a local increase in production. Water quality analyses show that the chloride concentration in this well has ranged from 2.9 to 7.7 mg/l, and the conductivity has ranged from 162 to 250 micromhos/cm.

Bywater Bay Well 2

Bywater Bay Well 2 is located in the southeast portion of the South Aquifer approximately 1¼ miles southeast of OWSI's Wells 13 and 14. Like Bywater Bay Well 1, Bywater Bay Well 2 is currently monitored by JCPUD. Water level and production data collected for the monitoring network are presented in Figure 18. This well was reportedly deepened from 254 feet to 323 feet in 1994. The static water level, at the time the well was deepened, was 252.2 feet. The initial monitoring water level (May 23, 1994) was 258.0 feet. In 2005, water levels ranged between 260.7 and 265.3 feet. The static water level data for this well reported between 1996 and present, indicate a continuous declining trend similar to Bywater Bay Well 1. However, as with Bywater

Bay Well 1, nearby wells (Hendrickson well and OWSI Wells 13 and 14) show stable trends for the same period, suggesting that the declining trend observed at Bywater Bay Well 2 is in response to a local increase in production during this period, similar to Bywater Bay Well 1. Production data for this well is relatively sparse, and it is difficult to accurately decipher a trend.

Water quality analyses for Bywater Bay Well 2 show that the chloride concentration has ranged from 5.0 to 19 mg/l, and the conductivity has ranged from 110 to 326 micromhos/cm. The overall water quality pattern shows a slightly increasing trend for both chloride and conductivity since 1994 through present. The trend is somewhat irregular though and does not definitively indicate saltwater intrusion. Both the chloride concentrations and the conductivity are well below current regulatory limits.

Shine Plat Well 2

The Shine Plat Well 2 is a community well located in the Shine area, outside the identified boundary of the South Aquifer. Measured water levels collected for the network are presented in Figure 19. The original static water level at construction in 1991 was reported to be at a depth of 2 feet. The initial monitoring water level (September 1993) was 14.8 feet. Subsequent water level measurements have been highly variable. In 2005, measured water levels ranged from 2.3 to 10.3 feet. This variability, which has been more prevalent in previous years, is likely caused by pumping activity in both this well and the nearby Shine Plat Well 1. Overall, however, a generally stable trend is represented by the highest recorded water levels since 1995. Water quality analyses show that the chloride concentration has ranged from 4.2 to 10 mg/l, and the conductivity has ranged from 183 to 255 micromhos/cm.

Hill Well

The Hill well is a private domestic well located on the southern fringe of the South Aquifer along the shoreline of Puget Sound in the Shine area. A hydrograph representing water levels collected for the network is presented as Figure 20. The original static water level at construction in 1983 was reported to be 30 feet. A water level of 36.5 feet was measured by Roats Engineering in September 1993. Subsequent measurements have showed considerable variation. This variability is likely a result of a combination of factors including pumping activity at the Hill well itself, seasonal variation, and possibly tides. In 2005, water levels ranged from 34.7 to 40.5 feet. Generally, the long-term water level pattern appears to indicate a declining trend since 1995.

Water quality analyses show that the chloride concentration in this well has ranged from 24 to 35 mg/l, and the conductivity has ranged from 339 to 475 micromhos/cm. Both the chloride and conductivity levels are relatively high compared to other wells in the network, suggesting minor saltwater influence, but not necessarily saltwater intrusion. The Hill well is located approximately 500 feet from the shoreline, and its static water level is, at times, approximately 10 feet above sea level with pumping water levels occasionally below sea level. The well location, water levels, and the completion elevation of 20 to 25 feet below sea level make the Hill well susceptible to saltwater intrusion. To date, however, water quality data collected for the monitoring network show stable to slightly declining chloride and conductivity levels, and no clear indication of an increased risk of saltwater intrusion.

Water Quality

The results from the most recent water quality analyses for the monitoring network are given in Table 2. For historical values, please refer to previous year-end summary reports. Historical water quality data show stable chloride concentrations and conductivity values for all the wells except for the Bywater Bay Well 2, which shows possibly a very slightly increasing trend. Further monitoring is needed to substantiate this apparent increase. The most recent water quality data show chloride concentrations and conductivity values are within the State drinking water standards for all wells in the network.

Table 2. Most recent water quality analyses of wells in the Port Ludlow area monitoring network

Well Name	Chloride (mg/l)	Conductivity (micromhos/cm)	Date sampled
Well 2	5.6	203	1/10/06
Well 3	5.5	197	1/10/06
Well 4N	<5.0	186	1/10/06
Well 4A	5	310	9/7/95
Well 9	4.9	245	2/20/96
Well 12	5	120	8/29/88 & 11/30/72
Well 13	<5.0	196	1/10/06
Well 14	<5.0	182	10/31/05
Well 15	5	184	2/5/05
Well 16	4	169	8/4/05
Devine Well	<5.0	223	10/8/03
Woodruff Well	<5.0	199	10/12/05
Neault Well	5.5	235	10/12/05
Hendrickson Well	5.5	179	10/12/05
JCWD#1 Paradise Bay Well	<5.0	147	10/11/05
JCPUD Bywater Well 1	5.3	212	10/12/05
JCPUD Bywater Well 2	10.5	314	10/12/05
Shine Plat Well 2	<5.0	235	10/11/05
Hill Well	28.9	415	10/11/05

Rainfall

Precipitation in the Port Ludlow area has been collected at the OWSI office since 1979. Plots of annual totals at Port Ludlow and at NOAA's Chimacum 4S weather station are given on Figure 21. The 27-year average for Port Ludlow is 32.64 inches per year (in/yr). This compares to the 26-year average at the Chimacum Station (2005 records not yet available for Chimacum) of 28.85 in/yr. The difference of 3.79 in/yr between the two locations is consistent with the isohyetal map in Water Supply Bulletin 54. However, the averages are greater at Port Ludlow and Chimacum than that suggested by the isohyetal map (which is based on 1931-1960 data).

Since 1991, rainfall has also been collected at a "South Bay" station located at Well 13. Rainfall in 2005 totaled 32.57 inches at the Port Ludlow office and 34.84 inches at the South Bay station. The 15-year average for the South Bay station is 33.88 in/yr.

Summary

Twelve years of monitoring have provided for an analysis of the condition of aquifers in the Port Ludlow area. The monitoring network, initiated in April 1994, currently includes 18 wells from seven participants, including four wells in the Shine area that are part of a Jefferson County PUD monitoring network.

In general, all wells in the network show seasonal variations. Water levels decline in the spring/summer months and rise in the fall/winter months. These variations are likely contributable to a combination of several factors. Most of the natural recharge to the aquifers occurs in the fall/winter, causing a rise in water levels. Then, increases in withdrawals from area aquifers during the spring through fall accentuate the normal decline in water levels occurring as a result of the natural discharge of the aquifers during the time of little or no recharge. Other non-seasonal factors, such as barometric effects (some wells have been shown to be nearly 100% efficient in the area), tidal effects, and measurements of post-pumping recovering water levels, add to the "noise" of the trend analyses. With the seasonal variations in mind, none of the aquifers within the monitoring network showed a significant overall decline from historical levels in 2005.

OWSI combined annual average production for 2005 was 206.2 gpm (332.6 acre feet) from all aquifers, down by 10.5 gpm (16.9 acre feet) from 2004. The decrease in production was likely associated with slightly higher annual rainfall than occurred during 2005 (therefore less irrigation usage). Since 2000, annual precipitation at Port Ludlow has been below average. Precipitation at Port Ludlow in 2005 was 32.57 inches, which is still slightly below the 27-year average of 32.64 in/yr, but up nearly 20% from the 2004 total of 27.2 inches.

In the North Aquifer, Wells 2, 3, and 4N show a general rise of water levels between 1993 and 2001. A programmed decrease in withdrawal rates from the aquifer was initiated in 1993. Water levels in Wells 2 and 3, and the private Woodruff Well, also completed in the North Aquifer, rose approximately five feet during that time. This rise was likely a direct result of the decreased withdrawal. However, over the past several years, water levels in Wells 2, 4N, and the Woodruff Well have declined slightly more than this amount, and in Well 3 nearly twice this amount. This recent decline is likely due to relatively low precipitation and increased production from the aquifer (specifically at Wells 2, 3, and 4N) that has occurred during this same period. In 2001, 2002, 2003, and 2004, withdrawal from the North Aquifer by OWSI was at a rate of 71.7 gpm (116 acre-feet/year), 78.0 gpm (126 acre-feet/year), 90.5 gpm (146 acre-feet/year), and 105.0 gpm

(170 acre-feet/year) respectively. In 2005, withdrawal from the North Aquifer by OWSI was at a rate of 108.0 gpm (174 acre-feet/year).

In the central portion of the South Aquifer, production at OWSI's Wells 13 and 14, and the JCWD #1 Paradise Bay Well has in general been steadily increasing since 1996. Production at Well 13 has decreased since 2003 because of problems with the well, and production was down slightly from the previous year at Well 14 and the Paradise Bay Well. The static water level in each of these three wells has been relatively stable over this time period. In 2003 and 2004, data indicate that the static water levels in Wells 13 and 14 declined slightly. No static water level data was received for the Paradise Bay Well in 2003, but measurement made in 2004 suggests a similar slight decline of the static water levels over the same two years. In 2005 water levels in Wells 13 and 14 appear to be stable again as compared to the previous year. No water level data was provided for the JCWD #1 Paradise Bay Well. The pumping water level in Well 13 was stable between 1996 and 1999. Between 1999 and 2003, the pumping water level in Well 13 steadily declined. This recent decline was determined through testing to be the result of declining efficiency. In 2004 and 2005, pumping levels in Well 13 reverted in direct response to significantly lower production levels. The pumping water level in Well 14, which was stable prior to 1996, has been steadily declining between 1996 and present. This steadily declining water level trend is likely in response to a general increase in production. Pumping water level data for the Paradise Bay Well are not available after 1996. There are currently no indications that water levels in the aquifer are declining significantly in this area.

For the southern portion of the South Aquifer, data for both the Bywater Bay Well 1 and Bywater Bay Well 2 show a possible decline in water levels since 1999. However, the inclusion of pumping and recovering water levels with the static water level data set may be presenting an erroneous trend. If the declining trend at these two wells is actually occurring, it is likely a local phenomena, probably related to an increase in production from each of the wells. Static water level data from the Paradise Bay Well and OWSI's Wells 13 and 14 to the north, and the private Henderickson Well to the west, indicate relatively stable levels for the aquifer in this area.

With the exception of the Devine Well, the private wells in the network located within 500 feet of the shoreline show highly variable water levels, the largest being up to 50 feet in Shine Plat Well 2. The variation in water levels are most likely the result of the combination of tides, barometric effects, seasonal recharge, and variations in pumping activity in the monitored wells and/or wells in their immediate vicinity. Even with these variations, the overall trends observed in the private wells appear to be steady, or slowly declining since 1999. The apparent decline in water levels is likely related to below average precipitation over the past several years.

In the South Valley Aquifer, water levels in Wells 4A, 9, and 12 show stable water levels with seasonal variations of up to four feet. These variations are most likely the result of variations in seasonal recharge.

Water quality results from the monitoring network wells show that chemistry has remained stable in all aquifers. The Hill well is the only well that shows chloride concentrations above normal background levels. This well shows a slightly elevated chloride level that, although well below the drinking water standard of 250 mg/l, is indicative of possible incipient saltwater intrusion. A chloride level of 28.9 mg/l was measured in October 2005. However, based on the thirteen years of chloride data, there is no indication of a trend toward increasing chloride levels in the Hill well.

In fact, concentrations have generally been decreasing since 1995. It may be possible that this level of chloride is natural for this portion of the aquifer.

Recommendations

The Port Ludlow groundwater monitoring program continues to function as designed. The current program provides adequate coverage and information on the aquifers in the Port Ludlow area. The continuation of monitoring water levels and water quality sampling in all network wells will allow long-term trend analysis of the aquifers in the Port Ludlow area. Based on the information gathered in 2005, the frequency of water level measurements can be maintained at quarterly intervals. Water quality sampling should remain on an annual basis, including the Hill well. It is also recommended that the monitoring of rainfall continue at the Olympic Water & Sewer's office and at the South Bay gage.

The monitoring program has collected a strong baseline of data and has provided an initial, long-term trend analysis. There are no definitive indications of declining water levels related to groundwater production or rising chloride and conductivity levels in any of the three aquifers monitored in the Port Ludlow area. The continuation of the monitoring program can insure that proper management of the groundwater resource is maintained.